Attachment 2. Emissions Reductions Calculations

Woodstove change outs

This goal of the woodstove and weatherization change out program in this proposal will be to replace 300 uncertified and non-EPA Step 2 certified stoves in and near the Klamath Falls Nonattainment Area with ductless heat pumps, and to offer rebates for 50 fireplace replacements with gas inserts. The tables below show the estimated emissions reductions for those device replacements.

For the woodstove emissions reductions calculations, we used default values for cords of wood burned per year, and the state average wood density of 1.03 for Oregon, and 100% change out to non-wood burning devices.

Table 2-1. EPA BurnWise Woodstove Calculator, tons per year emissions reduced for 300 conventional woodstoves changed out to ductless heat pumps.

Emission Avoided (tons)	
Pollutant	Total Emissions Avoided
CO	106.98
SO2	0.19
NO_X	1.30
VOC	24.57
$PM_{2.5}$-PRI	14.18
PM_{10}-PRI	14.18
Dioxin teq	0.000000002133
1,3-butadiene	0.1854
16-PAH	0.2966
7-PAH	0.0185
Acetaldehyde	0.2874
Acrolein	0.0464
Benzene	1.0012
Formaldehyde	0.6767
Methane	29.66
Napthalene	0.0834

total HAPS = 2.596

The calculator estimates that approximately 14.2 tons per year of $PM_{2.5}$ will be reduced if / when 300 wood stoves are replaced with non-wood burning devices. Over the average stove lifetime of 20-30 years, we estimate that a total of 284 to 426 tons of fine particulate matter could be prevented from entering the airshed if the devices had not been replaced. In addition, approximately 2.6 tons per year of hazardous air pollutants are prevented from entering the airshed.

Similarly, for fireplaces, we used the wood density for the State of Oregon, a burnrate of 1 (as specified by the calculator) and calculated the emissions reductions for 50 fireplaces replaced by gas inserts. Table 2-2 shows the results for fireplaces. The calculator shows a total reduction 0.6 tons per year $PM_{2.5}$ reduced emissions into the airshed, or over an expected average 50 year lifetime (the average life of a house), 30 tons reduced $PM_{2.5}$ emissions. In addition, 0.13 ton per year of hazardous air pollutants are estimated to be prevented from entering the airshed. Since hazardous air pollutants can have serious public health effects at low concentrations, the health benefits of their reduction greatly outweighs the tonnage reduced.

Table 2-2. EPA BurnWise Fireplace Calculator, tons per year of emissions reduced for 50 fireplaces to be replaced by gas inserts.

Emission Reduction (tons)	
Pollutant	Total Emissions Avoided
CO	6.51
SO_2	0.01
NO_X	0.07
VOC	0.49
$PM_{2.5}$-PRI	0.57
PM_{10}-PRI	0.57
Dioxin teq	0.0000000000203
1,3-butadiene	0.00405
16-PAH	0.01931
7-PAH	0.00567
Acetaldehyde	0.02752
Acrolein	0.00318
Benzene	0.01766
Formaldehyde	0.04618
Methane	0.37114
Napthalene	0.00682
Total HAPS	0.130

Diesel bus replacements with electric vehicles

Based on fleet information provided by the Director of Basin Transportation Services, Klamath Falls School District, and Klamath County School Distrcit, Oregon Department of Environmental Quality used the EPA Diesel Emissions Quantifier[1] to estimate fine particulate matter and precursor emissions reductions from a fleet upgrade to electric by 2025 (BTS) or fleet converstion to propane (school distrcits). We used the default information for annual fuel gallons and annual idling hours, and Biodiesel 5 as the available fuel type. Remaining vehicle life was calculated based on a 14 year life for buses as provided by the Federal Transit Authority or the anticipated vehicle retirement year when provided. Annual miles traveled were calculated based on actual vehicle mileage, and we assumed that a vehicle replacement to an all-electric vehicle would maximize the emissions reduced. Propane vehicles were assumed to use a similar amount of fuel.

Basin Transportation Services

Table 2-3. Fleet information for Basin Transportation Services, February 2020.

Year	Engine Year	Make	Model	Fuel Type	Miles Driven	Replacement Type	Replacement Year
1996	1996	Chance	Trolley	Diesel	29,743	Unknown	Unknown
2000	2017	Gillig	Bus - Large	Diesel	581,075	Unknown	2022
2001	2016	Gillig	Bus - Large	Diesel	590,016	Unknown	2022
2010	2010	Chevrolet	Bus - Small	Diesel	164,313	Unknown	True
2014	2014	Gillig	Bus - Large	Diesel	250,789	Unknown	2026
2014	2014	Gillig	Bus - Large	Diesel	251,863	Unknown	2026
2016	2016	Gillig	Bus - Large	Diesel	182,430	Unknown	2028
2016	2016	Gillig	Bus - Large	Diesel	186,127	Unknown	2028

[1] https://cfpub.epa.gov/quantifier/index.cfm?action=main.home (Accessed 2/7/20)

Year	Engine Year	Make	Model	Fuel Type	Miles Driven	Replacement Type	Replacement Year
2016	2016	Ford	Bus - Small	Gas	78,886	Unknown	2021
2016	2016	Ford	Bus - Small	Gas	53,885	Unknown	2021
2016	2016	Ford	Bus - Small	Gas	106,021	Unknown	2021
2016	2016	Blue Bird	Bus - Large	Diesel	117,097	Electric	2028
2016	2016	Blue Bird	Bus - Large	Diesel	122,427	Electric	2028
2019	2019	Ford	Van	Gas	4,079	Electric	2028

Table 2-4 shows the estimated maximum emissions reductions from the replacement of all the large diesel buses in the fleet with electric buses. The estimated reductions emissions are 100%, and approximately 0.45 tons of $PM_{2.5}$ and $PM_{2.5}$ precursors per year (NO_x + $PM_{2.5}$), and 3.66 tons NO_x + $PM_{2.5}$ over the remaining lifetime of the vehicles. The estimates used for the remaining life of the vehicles was based on the engine year and the Default Useful Life Benchmark for buses developed by the Federal Transit Administration (14 years), listed in Table 2-5.[2] In addition, 550 tons per year of carbon dioxide are expected to be prevented from entering the Klamath Basin Airshed, or 4,604 tons over the remaining lifetime of the vehicles, at a savings of 48,865 gallons of Biodiesel 5 per year or a lifetime savings of 409,248 gallons of fuel saved. We understand that the actual vehicles replaced will depend on the outcome of the feasibility study, and the cost effectiveness of various options may depend on costs able to be leveraged by Federal and State programs, such as Federal dollars available for public transportation vehicle purchases, and/or the recently passed Oregon State Transportation Improvement Fund.[3]

Table 2-4. Estimated Emissions Reduced for Basin Transportation Services Large Buses
Here are the combined results for all groups and upgrades entered for the project.[1]

Annual Results (short tons)[2]	**NO_x**	**PM2.5**	**HC**	**CO**	**CO_2**	**Fuel[3]**
Baseline for Upgraded Vehicles/Engines	0.441	0.007	0.027	0.107	549.7	48,865
Amount Reduced After Upgrades	0.441	0.007	0.027	0.107	549.7	48,865
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	3.602	0.061	0.222	0.880	4,604.0	409,248
Amount Reduced After Upgrades	3.602	0.061	0.222	0.880	4,604.0	409,248
Percent Reduced After Upgrades	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

[1] Emissions from the electrical grid are not included in the results.
[2] 1 short ton = 2000 lbs.
[3] In gallons; fuels other than ULSD have been converted to ULSD-equivalent gallons.
[4] Cost effectiveness estimates include only the costs which you have entered.

Table 2-5. Remaining Life of vehicle types in Basin Transportations fleet (February 2020)

Vehicle or Engine Group	Remaining Life
2000 Gillig: Transit Bus | Transit Buses | Vehicle Replacement - All-Electric	11 years
2001 Gillig: Transit Bus | Transit Buses | Vehicle Replacement - All-Electric	10 years
2014 Gillig: Transit Bus | Transit Buses | Vehicle Replacement - All-Electric	7 years

[2] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA%20TAM%20ULB%20Cheat%20Sheet%202016-10-26.pdf (Accessed 2/7/20)
[3] https://www.oregon.gov/ODOT/RPTD/Pages/STIF.aspx (Accessed 2/7/20)

Vehicle or Engine Group	Remaining Life
2016 Gillig: Transit Bus | Transit Buses | Vehicle Replacement - All-Electric	8 years
2016 Blue Bird: Transit Bus | Transit Buses | Vehicle Replacement - All-Electric	8 years

Klamath Falls School District Diesel Bus Replacements

Klamath Falls School District submitted the following buses out of their entire fleet for replacement (Table 2-6). This does not include models of vehicles that are likely to be replaced by either DERA funding or VW settlement monies. We estimate the cost of bus replacements at $130,000 per vehicle.

Table 2-6. Klamath County School District fleet – vehicle upgrades to propane

MAKE	YEAR	Number	FUEL	ENGINE	Average 18-19 Mileage
Blue Bird	1998	1	DIESEL	CUMMINS 8.3	1936
Blue Bird	1999	2	DIESEL	CUMMINS 8.3	3890
Blue Bird	2000	13	DIESEL	CUMMINS 8.3	3761
Blue Bird	2004	1	DIESEL	CUMMINS 8.3	2030
Int'l	2005	1	DIESEL	INT. DT 466	6688

Table 2-7 shows the estimated maximum emissions reductions from the replacement of all the large diesel buses in the fleet with propane injection engines. The estimated $PM_{2.5}$reductions emissions are 96.3% annually, and approximately 1.1 tons of $PM_{2.5}$ and $PM_{2.5}$ precursors per year (NO_x + $PM_{2.5}$), and 2.38 tons NO_x + $PM_{2.5}$ over the remaining lifetime of the vehicles. The estimates used for the remaining life of the vehicles was based on the engine year and the estimated remaining useful based on the school district's planned retirement year.[4] We understand that the actual vehicles replaced will depend on the cost effectiveness of various options may depend on costs able to be leveraged by Federal and State programs, such as Federal dollars available for public transportation vehicle purchases, and/or the recently passed Oregon State Transportation Improvement Fund.[5]

Table 2-7. Estimated Emissions Reduced for Klamath Falls School District Large Diesel School Buses

Annual Results (short tons)[2]	NO_x	PM2.5	HC	CO	CO_2	Fuel[3]
Baseline for Upgraded Vehicles/Engines	1.036	0.074	0.197	0.452	274.4	24,389
Amount Reduced After Upgrades	0.981	0.071	0.174	0.158	59.5	5,291
Percent Reduced After Upgrades	94.8%	96.3%	88.7%	34.9%	21.7%	21.7%
Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	2.217	0.160	0.413	0.977	594.5	52,843
Amount Reduced After Upgrades	2.098	0.154	0.365	0.333	129.0	11,464
Percent Reduced After Upgrades	94.7%	96.2%	88.2%	34.1%	21.7%	21.7%

[1] Emissions from the electrical grid are not included in the results.
[2] 1 short ton = 2000 lbs.
[3] In gallons; fuels other than ULSD have been converted to ULSD-equivalent gallons.

Table 2-8. Remaining Life of vehicle types in Klamath Falls School District.

[4] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA%20TAM%20ULB%20Cheat%20Sheet%202016-10-26.pdf (Accessed 2/7/20)
[5] https://www.oregon.gov/ODOT/RPTD/Pages/STIF.aspx (Accessed 2/7/20)

Vehicle or Engine Group	Remaining Life
2000 Blue Bird: School Bus | School Buses | Engine Replacement - LPG/Propane	2 years
1999 Blue Bird: School Bus | School Buses | Engine Replacement - LPG/Propane	2 years
1998 Blue Bird: School Bus | School Buses | Engine Replacement - LPG/Propane	2 years
2004 Blue Bird: School Bus | School Buses | Engine Replacement - LPG/Propane	2 years
2005 International: School Bus | School Buses | Engine Replacement - LPG/Propane	5 years

Klamath County School District Diesel Bus Changeouts

Klamath County School District submitted the following buses out of their entire fleet for replacement with propane. This does not include models of vehicles that are likely to be replaced by either DERA funding or VW settlement monies. We estimate the cost of bus replacements at $130,000 per vehicle.

Table 2-9. Klamath County School District fleet – vehicle upgrades to propane

Year	Make	Model	Quantity	Engine Year	Avg Annual miles	Annual fuel use (gallons)
1993	BlueBird	All American	4	1993	2,619	409
1994	BlueBird	All American	1	1994	1,944	303
1994	Bluebird	TCFE	1	2003	14,057	2,194
1996	BlueBird	TCFE 2803	1	1996	4,716	736
2000	Bluebird	All American	12	2000	10,455	1,632
2000	Thomas	MVPEF	1	2000	4,882	762
2003	Ford	E350	3	2003	1,336	2,085
2004	Thomas	FS 65 Conventional	2	2004	18,497	2,887

Table 2-10 shows the estimated maximum emissions reductions from the replacement of all the large diesel buses in the fleet with propane injection engines. The estimated $PM_{2.5}$reductions emissions are 96.3% annually, and approximately 1.88 tons of $PM_{2.5}$ and $PM_{2.5}$ precursors per year (NO_x + $PM_{2.5}$), and 3.59 tons NO_x + $PM_{2.5}$ over the remaining lifetime of the vehicles. The estimates used for the remaining life of the vehicles was based on the engine year and the anticipated retired year as provided by the school district.[6] We understand that the actual vehicles replaced will depend on the cost effectiveness of various options may depend on costs able to be leveraged by Federal and State programs, such as Federal dollars available for public transportation vehicle purchases, and/or the recently passed Oregon State Transportation Improvement Fund.[7]

Table 2-10. Estimated Emissions Reduced for Klamath County School District Large Diesel School Buses

Annual Results (short tons)[2]	NO_x	PM2.5	HC	CO	CO_2	Fuel[3]
Baseline for Upgraded Vehicles/Engines	1.858	0.126	0.313	0.766	417.4	37,105
Amount Reduced After Upgrades	1.764	0.121	0.275	0.264	146.6	13,029
Percent Reduced After Upgrades	94.9%	96.3%	87.9%	34.4%	35.1%	35.1%

[6] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA%20TAM%20ULB%20Cheat%20Sheet%202016-10-26.pdf (Accessed 2/7/20)
[7] https://www.oregon.gov/ODOT/RPTD/Pages/STIF.aspx (Accessed 2/7/20)

Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	3.541	0.252	0.610	1.554	1,041.4	92,569
Amount Reduced After Upgrades	3.347	0.243	0.532	0.522	368.0	32,708
Percent Reduced After Upgrades	94.5%	96.2%	87.3%	33.6%	35.3%	35.3%

[1] Emissions from the electrical grid are not included in the results.
[2] 1 short ton = 2000 lbs.
[3] In gallons; fuels other than ULSD have been converted to ULSD-equivalent gallons.

Table 2-11. Remaining Life of vehicle types in Klamath County School District.

Vehicle or Engine Group	Remaining Life
2000 BlueBird: School Bus | School Buses | Engine Replacement - LPG/Propane	2 years
2004 Thomas FS 65: School Bus | School Buses | Engine Replacement - LPG/Propane	4 years
1993 BlueBird: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
1994 BlueBird: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
1996 BlueBird: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
2000 Thomas: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
1994 BlueBird: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
2003 Ford E350: School Bus | School Buses | Engine Replacement - LPG/Propane	4 years

Migrant Head Start / OCDC Diesel school bus changeouts

Migrant OCDC provided the following information to DEQ for VW Settlement bus changeouts. DEQ took only the large diesel buses for emissions reductions estimates. Conversion to propoane is estimated at $130,000.

Table 2-12. Oregon Child Development Center - Klamath County fleet – vehicle upgrades to propane

District Name	Bus Body Year	Bus Body Make Code	Quant	Bus Body Type Code	Bus Passenger Capacity	Bus Fuel Type Code	Bus Number
OCDC- KLAMATH CO.	2001	BB	2	D	78	DIES	91, 94
OCDC- KLAMATH CO.	2003	BB	3	D	84	DIES	12, 13, 14

Table 2-13 shows the estimated maximum emissions reductions from the replacement of all the large diesel buses in the fleet with propane injection engines. The estimated $PM_{2.5}$ reductions emissions are 96.0% annually, and approximately 0.58 tons of $PM_{2.5}$ and $PM_{2.5}$ precursors per year ($NO_x + PM_{2.5}$), and 0.58 tons $NO_x + PM_{2.5}$ over the remaining lifetime of the vehicles. The estimates used for the remaining life of the vehicles was based on the engine year and the anticipated retired year as provided by the school district.[8] We understand that the actual vehicles replaced will depend on the cost effectiveness of various options may depend on costs able to be leveraged by Federal and State programs, such as Federal dollars available for public transportation vehicle purchases, and/or the recently passed Oregon State Transportation Improvement Fund.[9]

[8] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA%20TAM%20ULB%20Cheat%20Sheet%202016-10-26.pdf (Accessed 2/7/20)
[9] https://www.oregon.gov/ODOT/RPTD/Pages/STIF.aspx (Accessed 2/7/20)

Table 2-13. Estimated Emissions Reduced for Migrant OCDC - Klamath County Large Diesel School Buses

Annual Results (short tons)[2]	**NO_x**	**PM2.5**	**HC**	**CO**	**CO_2**	**Fuel**[3]
Baseline for Upgraded Vehicles/Engines	0.544	0.040	0.085	0.253	76.2	6,775
Amount Reduced After Upgrades	0.510	0.038	0.072	0.077	26.5	2,355
Percent Reduced After Upgrades	93.7%	96.0%	84.7%	30.3%	34.8%	34.8%
Lifetime Results (short tons)[2]						
Baseline for Upgraded Vehicles/Engines	0.544	0.040	0.085	0.253	76.2	6,775
Amount Reduced After Upgrades	0.510	0.038	0.072	0.077	26.5	2,355
Percent Reduced After Upgrades	93.7%	96.0%	84.7%	30.3%	34.8%	34.8%

[1] Emissions from the electrical grid are not included in the results.
[2] 1 short ton = 2000 lbs.
[3] In gallons; fuels other than ULSD have been converted to ULSD-equivalent gallons.

Table 2-14. Remaining Life for vehicles in Migrant OCDC – Klamath county.

Vehicle or Engine Group	**Remaining Life**
2001 BB: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year
2003 BB: School Bus | School Buses | Engine Replacement - LPG/Propane	1 year